

Organization(s): Duke University

Title: Microfluidic Operations and Network Architectural Characterizations (MONARCH)



MTO

**Composite
CAD**

Duration of Effort: July 1998 - July 2001

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Objectives:

The objective of the MONARCH research program is to design and evaluate an architecture for reconfigurable biochips supporting biomedical applications. The architecture will enable reconfigurable and reusable integration of component-level technology involving pumps, valves, reservoirs, channels, and sensors to support a variety of protocols in continuous-flow microchemical analysis and precision microdosing. Alternative implementations in a unit-flow technology have also been developed. We intend to demonstrate a reconfigurable unit flow architecture that will be suitable for various classes of biomedical operations. A hierarchical modeling and simulation capability has been developed encompassing process flow, stochastic performance, and nodal circuit levels of abstraction using SystemC as a modeling language. We have explored the limitations of VHDL-AMS and other languages in microfluidic applications, and System C is the most versatile. Develop an intelligent substrate technology.

Major Accomplishments:

- MONARCH biochip unit-flow architecture/applications assessment completed for v2.0
- Completed demonstration of a hierarchical MEFS design environment for continuous flow systems based on SystemC as a common modeling language. The system allows hierarchical modeling, hierarchical performance evaluation, and hierarchical optimization.
- Used hierarchical simulation to evaluate various architectures for a PCR system. Droplet-based PCR system was shown to be far superior in throughput, size, and reconfigurability.
- Demonstrated that electrowetting-based droplet mixing occurs over 30 times faster than diffusion mixing - allows 4 second processing.
- Applied integer linear programming models in describing the scheduling of a reconfigurable, unit flow architecture.
- Demonstrated self-aligned dynamic stamping of DNA microarray spots using droplets.

DOD Impact:

- Developed and demonstrated first practical unit flow microfluidics technology, which enables reconfigurable microfluidic systems with 1 uW/droplet power dissipation.
- Develop first top-down design approach and tools for reconfigurable MEFS.
- Hierarchical design of droplet-based microfluidic systems will facilitate design from the applications level.

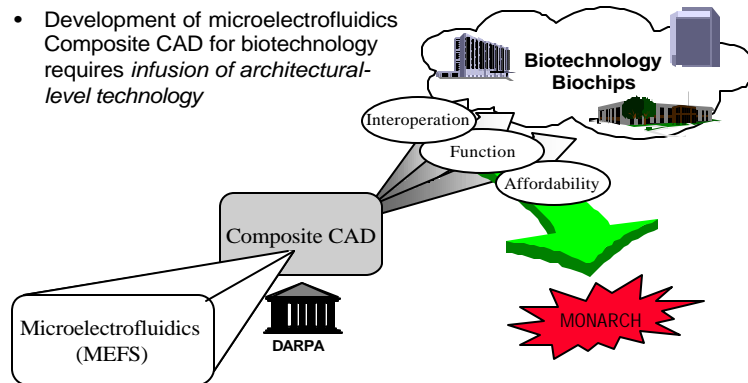
Technology Transfer/Products:

- Unit flow MEFS technology has been transferred to a start-up company, Nanolytics.
 - Flumetrics, Inc. established to develop droplet-based analytical systems.
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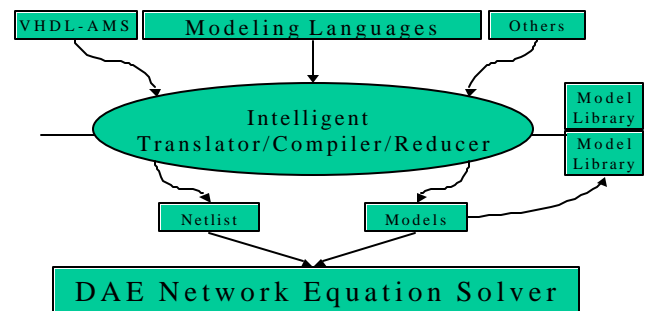
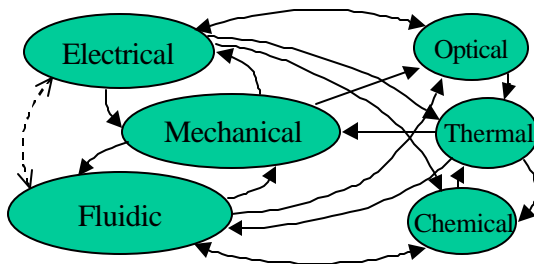
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- MONARCH is developing a system-level composite CAD link in MEFS design

- Development of microelectrofluidics Composite CAD for biotechnology requires *infusion of architectural-level technology*



- MONARCH is focusing on reconfigurable architecture that performs canonical operations that support biomedical applications
- MONARCH is doing MEFS system simulation with a more applicable 'engineering solution' to simulation and interfacing to existing modeling efforts via a 'model compiler' with automatic reduced-order model generation



- Novel technology platforms in unit flow technology for reconfigurable architectures:

